Utilization of AVL with OLS on students' motivation and common misconceptions in cell division

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ABSTRACT

COVID-19 pandemic exhausted the learning resources in the educational system of the Philippines. This situation called for learning materials to supplement the teaching-learning process while in distance education. Hence, this paper utilized asynchronous video lectures (AVL) infused with online learning simulators (OLS) to supplement learning approaches in teaching cell division. Specifically, the goal of this study is to asses the students' motivation as well as their common misconceptions in learning cell division. Using students' motivation towards science learning (SMTSL) questionnaire, it was found that the learners are moderately motivated in general and are low to highly-motivated in other areas considered. These results may be associated to the absence of teacher and student interaction. Using the relational and structural scoring of concept maps, it was found that the concept map scores of the learners before and after the use of AVL with OLS were found to be significant. This implies that the misconception of the learners has significantly improved. With this, the AVL with OLS can be utilized as a learning supplement to teach cell division with recorded moderate levels of motivation among learners as well as the significant improvement in the misconceptions among them. Nonetheless, more improvements may be applied to boost the motivation levels among learners.

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1. INTRODUCTION

During COVID-19 pandemic, the Philippines has taken a huge step in implementing different modes of distance instruction to extend teaching and learning to each student [1]. Several higher education institutions utilized the conduct of synchronous and asynchronous approach in distance education including some private schools that offer basic K to 12 educations [2]. In a meta-analysis of several studies [3]–[8], it was observed that the learning materials in the asynchronous learning approach, like the use of asynchronous video lectures (AVL) with online learning simulators (OLS), can be utilized and serve as supplements in different learning setups even in the traditional face-to-face classes.

When compared to the synchronous approach in an online learning environment, the nature of the asynchronous mode allows more reflection, equitable opportunities to participate, more active learning, and fewer technical issues according to Lowenthal *et al*. [9]. This is where the asynchronous video lecture stands out plus its usability in both set-ups. From the study by Guo *et al*. [10], they compared types of AVL using student engagement in a massive open online course platform called edX that was created and hosted by Massachusetts Institute of Technology and Harvard. They found that informal talking-head videos and the Khan-style tablet drawings were more engaging than other types of videos and that students engage differently with lecture and tutorial videos. Another study by Ng and Przybylek [11] examined the effects on visual attention of the presence of the instructor. Their results suggested that students who watched AVL that included the instructor's face achieved better learning results with less effort than did students who watched the AVL without the image of the instructor. With its individualized learning attribute, both face-to-face and online students can pause, rewind or repeat the AVL which allows the student to review for tests and to revisit complex concepts or topics for deeper understanding and increased retention [12]‒[15]. The 'second look' at the concept allows a better understanding and offers greater comprehension of difficult concepts than the textbook or PowerPoint slides, thus reducing the need to contact the instructor for clarification [16]‒[18]. Other researchers have also shown that after using AVL, students tend to feel they have enhanced understanding of concepts while some studies indicated better learning outcomes and performances as evidenced by improved grades [19]‒[23].

Aside from AVL, virtual technology is able to improve the construction of analogies of natural phenomena via visual representations and contrived simulations based on the real phenomena [24]‒[26]. Although direct experiences and hands-on activities are considered crucial to accomplishing laboratory tasks, using computers as learning materials in the form of OLS allow students to take part in activities which are not available in the laboratory. The teaching strategies that copy real-life scenarios through OLS are expected to improve the scientific skills, misconceptions, and conceptual understanding of the students [27]‒[30].

However, video lectures and online simulators are mostly utilized separataley in previous studies. This served as a motivation to combine the two asycnrhonous video lectures (AVL) with online learning simulator (OLS) in this study. The AVL with OLS is grounded on transactional distance theory, scaffolding theory, and an inquiry-based approach. This theory emphasized that Transactional distance in online learning is a function of three variables which are the dialogue, structure, and learner autonomy. All three of which must be considered in the distance mode of instruction; hence the researcher used this theory as a basis for the communication framework during the implementation of the developed AVL [31]. Since the AVL developed in the study contains discussions and activity instructions, the scaffolding theory of Jerome Bruner will also be utilized as another guiding principle in creating the video lecture. Scaffolding theory refers to a process wherein teachers' model or demonstrate how to solve a problem, and then step back, offering support as needed [32]. The support and intervention were provided via instant messaging platforms since it was implemented in asynchronous mode. In addition, the development of asynchronous video lecture (AVL) was aided by OLS that facilitate an inquiry-based approach to teaching cell division through the big questions and a series of queries in the AVL with OLS. Inquiry-based approach is a form of active learning that starts by posing questions, problems, or scenarios-rather than simply presenting established facts or portraying a smooth path to knowledge [33].

The content of the AVL with OLS was focused on the scientific concepts of cell biology specifically cell division which covers mitosis and meiosis. Cell biology, which includes cell division, is one of the difficult topics in biology because of its broad and complex nature [34], [35]. In addition to this, there are tons of concepts and terminologies that one should familiarize himself. With this, misconceptions are rampant as reported in a large number of prior studies [36]‒[39]. These persisting misconceptions in scientific concepts are contributory to the consistent low academic achievement among Filipino learners as evidenced in the low-performance scores and low overall rankings in science and mathematics in the 2018 Programme for international student assessment (PISA) and the 2018 national achievement test [40].

Furthermore, Aque *et al*. [41] also recommended that academic institutions, as well as learning facilitators, should put the motivation of learners into consideration in implementing science education in an asynchronous environment. In science education, especially in teaching abstract concepts in science, motivation is a vital factor that contributes to the enhancement of students' misconceptions of the different lessons in science [42]. This element describes the willingness of the learners to deeper understand the concepts in science like focus of this study on cell division. Hence, the main purpose of this study is i) to assess the students' motivation in learning cell division through the use of AVL with OLS; and ii) to assess the common misconceptions in cell division through the use of AVL with OLS. The importance of this study lies on the importance of students' motivation in scientific learning as it is a contributing factor that helps them realize various affective area in extending effort to learn scienctific concepts. Additionally, the integration of technology in the lesson in the form of video lectures and online simulators helps to combat persisting misconceptions among learners making it difficult for many of them to understand higher concepts in biology due to unreliable foundation of science concepts like cell division.

2. METHOD

This study utilized descriptive quantitative research design through the collection of quantitative data utilizing specific instruments. The respondents of this study are students from schools in Iligan City, Philippines following the purposive sampling method. In this study, the student's motivation towards science learning was assessed through the use of an adapted Likert scale questionnaire while the misconception of the students regarding cellular division was assessed through concept maps. Purposive sampling was also used in selecting the respondents to the mode of learning of the respondents during the period of the COVID-19 pandemic. The school and the respondents who provided the option of asynchronous mode of learning were the main consideration of this study. This research design served as the foundation in analyzing the collected data through the use of descriptive statistics.

2.1. Research instruments

2.1.1. Asynchronous video lecture with online learning simulators

The AVL with OLS served as the supplemental learning material implemented in the respondent school following purposive sampling. The said learning material has undergone expert validation from the content experts, multimedia experts, science education experts, and secondary in-service teachers. After validation, necessary improvements were done based from the expert validation and it underwent pilot testing.

2.1.2. Students' motivation towards science learning (SMTSL) questionnaire

This instrument was adapted from Tuan *et al*. [43] in order to determine the balance between dialogue, structure, and autonomy of transactional distance theory based on the learners' motivation. The SMTSL questionnaire has a high internal consistency based on its Cronbach alpha (α=0.89).

2.1.3. Standard concept map and scoring guide

The standard concept map was created by the researcher and face validated by science education experts and biology teachers. The standard concept map served as the basis to evaluate the concept maps that were created by students before and after the use of the AVL with OLS. A scoring guide based on McClure *et al*. [44] was also used to assess the concept maps of the respondents.

2.2. Data gathering procedure

This study underwent three major phases: (phase I) utilization of the AVL with OLS, (phase II) assessment of students' motivation and common misconception, and (phase III) analysis of data. During phase I, the AVL with OLS was implemented in the selected respondents following purposive sampling. The same respondents were given the SMTSL questionnaire and they were given the task to do the pre and post concept map making.

The data collected from the SMTSL questionnaire was analyzed using descriptive statistics and interpreted accordingly to support the data for SMTSL. On the other hand, the concept map scores before and after the use of the AVL with OLS were collected using the relational and structural scoring guide. The two data sets were analyzed using t-test for the common misconceptions.

2.3. Data analysis

2.3.1. SMTSL questionnaire rating interpretation

The mean scores from the SMTSL was interpreted using Cavas [45] classification system as shown in Table 1. The corresponding mean ranges determined the level of motivation of the learners in this study. It may be identified whether the students' motivation is high, moderate, or low.

Table 1. The mean ranges and description in interpreting students' motivation results

Mean ranges	Description
4.41-5	High-level motivation
3.39-4.4	Moderate-level motivation
1-3.38	Low-level motivation

2.3.2. Relational scoring and structural scoring of concept maps

The relational scoring guide protocol of McClure *et al*. [44] followed by the researcher in scoring the concept map outputs of the learners. This scoring protocol considers the relationships between the concepts branched and linked in a concept map. Respective points are designated on each relationship correctly connected or linked concepts.

The structural scoring guide McClure *et al*. [44] followed by the researcher in scoring the concept maps made by the learners. This scoring protocol mainly considers the prepositions, hierarchies, cross-links, and examples specified in the concept map. Specific scores are also designated on each component ranging from 1, 5, 10, to 1.

3. RESULTS AND DISCUSSION

3.1. Students' motivation in the implementation of the AVL with OLS

In the study of Tuan *et al*. [43], it was emphasized that science teaching and learning should not only focus solely on the learners' cognition but similar attention must also be given to the affective component of cognition. Of the different affective components, motivation is considered an important factor because it plays an important role in learners' conceptual change processes [46]‒[48]. With this, the researcher administered the student motivation towards science learning (SMTSL) questionnaire of Tuan *et al*. [43] with a Cronbach alpha of α=0.89 to assess the students' motivation on specific motivation parameters in the implementation of AVL with OLS in an asynchronous environment.

This aligns with the ultimate goal of this paper to assess the motivation of the students towards learning science, in this case- cell division. This gives a strategic view not only to focus on the conceptual understanding of the students but also to look at their affective aspect.

The result from the students' responses revealed that the learners are moderately motivated (mean=3.542) after the use of AVL with OLS in an asynchronous environment as shown in Table 2. In addition, the learners are also moderately motivated in other areas such as self-efficacy, active learning strategies, science learning value, achievement goals, and learning environment. The highest identified area is the achievement goal. According to Razali *et al*. [49], students are intrinsically motivated when they have an achievement goal and they intend to accomplish something to satisfy their innate needs for improving their own competence hence, the achievement of valuable goals like science learning. It was followed by science learning value which refers to whether or not students can perceive the value of science learning they engage in. And self-efficacy refers to the individual's perception of his/her ability in accomplishing learning tasks [50]. Lastly, the learners are moderately motivated in active learning strategies. In constructivist learning, students take an active role in interacting with the environment. In other words, they use active learning strategies to retrieve existing knowledge to interpret new experiences in order to construct new understanding.

On the other hand, the result suggests that the learners are least motivated in terms of performance goals. A similar result was also observed in the study of Aque *et al.* [41]. This means that the learners do not compete with other students and do not get attention from the teacher [43].

According to the cited literatures of this study [48], [51], it was highlighted that learners will be concerned more with performing better than their peers and impressing their teachers if their goal towards tasks is for performance. In this study, however, the students cannot directly compete with their peers and impress their teacher since the AVL with OLS was conducted in an asynchronous environment. The absence of teacher and student interaction is considered a factor that caused the low motivation of the students in relation to a performance goal.

Table 2. Results of SMTSL in the use of AVL with OLS

SMTSL components	Mean	Description	Rank
SMTSL overall	3.86	Moderate	
Self-efficacy	3.80	Moderate	4
Active learning strategies	3.96	Moderate	3
Science learning value	4.09	Moderate	2
Performance goal	3.38	Low	6
Achievement goal	4.17	Moderate	1
Learning environment stimulation	3.74	Moderate	5

3.2. Misconception assessment of the learners in the implementation of the AVL with OLS

3.2.1. Misconception of students based on concept map scores

The researcher analyzed the total scores of concept maps made by the students following the protocol for the relational and structural scoring method of McClure *et al*. [44]. The total scores of the concept maps were derived from both relational and structural scores using a 50%-50% weight ratio as recommended in the study by Barquilla [52].

Table 3 shows the comparison in the concept maps scores of the learners before and after the use of

AVL with OLS in an asynchronous learning environment. The mean concept map score before the use of AVL with OLS is 16.08 with a standard deviation of 5.40 while the mean concept map score after the use of AVL with OLS is 22.85 with a standard deviation of 7.00. These statistical results suggest that there is a positive increase in the concept map scores of the learners before and after the use of AVL with OLS and a closer standard deviation implies that the sample population is homogenous.

Based on the paired t-test result, there is a significant difference in the concept map scores before the use of AVL with OLS (M=16.08, SD=5.40) and after the use of AVL with OLS (M=22.85, SD=7.00) conditions; t (29)=-8.30, p=0.000. This implies that the misconception of the learners regarding cellular division has significantly improved after the AVL with OLS was implemented in the asynchronous learning environment.

The misconception assessment result in this study further supports the result in the learners' achievement test (pre-test and post-test) suggests that the conceptual understanding of the learners has improved after the use of AVL with OLS in an asynchronous learning environment. These results are supported by the studies of Ishak *et al*. [18] and Saluky and Bahiyah [53] which emphasize the enhanced conceptual understanding among learners and bridging the information gap among learners thereby, improving their misconceptions through the use of AVL with OLS.

Table 3. Comparison of the students' concept map scores before and after the use of AVL with OLS

Before the use of AVL with OLS		After the use of AVL with OLS		N	Mean difference	SD	p	t	df
M	SD	M	SD						
16.08	5.40	22.85	7.00	30	-6.78	4.48	.000	-8.30*	29

Note: *Significant at α=0.05 level

3.2.2. Improved misconceptions

In the study of Watson *et al*. [54], the use of concept maps is an effective tool in assessing the misconception and conceptual understanding of the learners about a certain concept, topic, or idea. With this, the researcher administered two concept map assessments to compare whether there is a difference between the concept map scores before and after the use of AVL with OLS. Specific protocols in scoring the concept maps created by learners were observed by the researcher and the total scores of the concept maps were derived from both relational and structural scores using a 50%-50% weight ratio as recommended in the study by Barquilla [52].

A teacher-made concept map was used as a basis for scoring the concept maps created by the learners following the protocol for the relational and structural scoring method of McClure *et al*. [44]. The teacher-made concept map was also evaluated by science education experts and biology teachers using a concept map rubric adapted from Watson *et al.* [54].

In this study, the researcher assessed the existing misconceptions of the learners regarding cellular division as shown in Table 4. Using the relational scoring protocol of McClure *et al*. [44], the researcher identified nine misconceptions of the learners before the use of AVL with OLS. One of the common misconceptions that can be observed in the concept map outputs of the learners is "prophase has prophase I and prophase II". Similar findings are also observed in the study of Akinbadewa and Sofowora [55] and Funa and Talaue [56] where misconceptions are rooted in the difficulty of the learners in determining whether or not certain processes or phases occur in mitosis, meiosis, or both.

After the use of AVL with OLS, all of the nine identified misconceptions were improved. The misconception about meiosis and its different phases was corrected after the use of AVL with OLS. Similarly, the observed misconceptions in mitosis and the four phases it encompasses were also improved along with the correct number of chromosomes produced in both mitosis and meiosis.

These results imply that the learners' misconceptions concerning cellular division have improved after the use of AVL with OLS. In the initial result during the try-out phase, the 1 misconception was sustained even after the use of AVL with OLS. On the other hand, all the misconceptions during the final implementation were improved after the use of AVL with OLS. This suggests that the improvements made based on the conduct of the try-out phase were effective in addressing the misconception about meiosis.

In this study, the researcher also assessed the correct conceptions of the learners regarding cellular division. Following the relational scoring protocol of McClure *et al*. [44], the researcher identified 9 correct conceptions of the learners before the use of AVL with OLS. The 3 of the correct conceptions have no changes while 4 correct conceptions are further improved signified with a positive sign (+) after the use of AVL with OLS in an asynchronous learning environment. These results imply that the learners correct conceptions concerning cellular division have improved and were sustained after the use of AVL with OLS as similarly observed during the try-out phase of the AVL with OLS. These results indicate that the improvement made by the researcher following the observed insufficiencies during try-out is effective in improving the misconception of the learners. Meaning, the learners had a better grasp on how the different stages of mitosis and meiosis, and cell division, in general, works in the human body.

Table 4. Improved misconceptions before and after the use of AVL with OLS

Before using AVL with OLS	Remarks	After using AVL with OLS	Remarks
Meiosis is divided into metaphase I and metaphase II.	-	Meiosis is divided into meiosis I and meiosis II.	+
Mitosis has 23 chromosomes each cell.	-	Mitosis produces 2 new cells with 46 chromosomes each.	+
Meiosis has 46 chromosomes each cell.	-	Mitosis produces 4 new cells with 23 chromosomes each.	+
Anaphase I and anaphase II in mitosis.	-	Mitosis has prophase, metaphase, anaphase, and telophase (PMAT).	+
Prophase has prophase I and prophase II.	-	Prophase in mitosis while prophase I in meiosis I and prophase II in meiosis I.	+
Prophase I is followed by prophase II and metaphase I is followed by metaphase II.	-	In meiosis I, the four phases are prophase I, metaphase I, anaphase I, and telophase I. In meiosis II, the four phases are prophase II, metaphase II, anaphase II, and telophase II.	+
Metaphase II produces 4 haploid cells.	-	Meiosis II produces 4 haploid cells.	+
Mitosis contains germ cells.	-	Mitosis occurs in germ cells.	+
Meiosis II has PMAT I and II.	-	Meiosis I has PMAT I and meiosis II has PMAT II.	+

Note: (+) correct conception, (-) misconception, no change (same conception but either correct conception (+) or misconception (-))

4. CONCLUSION

In general, it was found that the utilization of the asynchronous video lecture with online learning simulator can moderately motivate students and significantly improve their misconception in understanding cell division. The results from the STMSL questionnaire showed moderate implication in terms of student's motivation towards science learning while the concept map scores suggest significant improvement in the students' misconceptions before and after using AVL with OLS. Furthermore, the following conclusions were formulated in this study. The learners are moderately motivated in self-efficacy, active learning strategies, science learning value, achievement goal, and learning environment while the learners are least motivated in terms of the performance goal. Nontheless, the other parameters indicated moderate levels so it suggests that the AVL with OLS can be used as a learning supplement in teaching cell division. This further implies that there is a need to apply more improvements and modifications to the AVL with OLS in order to leverage the low motivation among learners in terms of the performance goals. The misconceptions of the learners regarding cellular division have significantly improved after the AVL with OLS was implemented in the asynchronous learning environment. In other words, the use of AVL with OLS can motivate the learners in learning science concepts like cell division and improve the existing misconceptions about the topic.

In the conduct of the SMTSL questionnaire, further research on asynchronous learning may also administer this questionnaire before and after the use of a developed product. This is to assess whether the motivation of the learners improved before the asynchronous learning material and after it was used. Teachers can use AVL with OLS to cover other topics in order to improve the misconceptions of the learners. Additionally, the identified misconceptions in the study can also be used as a basis for developing other instructional materials that aim to address the consistent misconceptions among learners concerning cell division.

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AUTHOR CONTRIBUTIONS STATEMENT

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C : **C**onceptualization	I : **I**nvestigation	Vi : **Vi**sualization
M : **M**ethodology	R : **R**esources	Su : **Su**pervision
So : **So**ftware	D : **D**ata Curation	P : **P**roject administration
Va : **Va**lidation	O : Writing - **O**riginal Draft	Fu : **Fu**nding acquisition
Fo : **Fo**rmal analysis	E : Writing - Review & **E**diting	

CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

INFORMED CONSENT

We have obtained informed consent and assent from all individuals included in this study.

ETHICAL APPROVAL

The research related to human use has been complied with all the relevant national regulations and institutional policies in accordance with the ethical policies implemented and reinforced in Mindanao State Unviversity-Iligan Institute of Technology

DATA AVAILABILITY

The data that support the findings of this study are available on request from the corresponding author, [EGGE]. The data, which contain information that could compromise the privacy of research participants, are not publicly available due to certain restrictions.

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